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LHC CIVIL ENGINEERING CONSTRUCTION CONTRACTS – COST MONITORING AND BUDGET FORECASTING

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Abstract

The Civil Engineering project for the LHC is estimated at 350 MCHF, of which about 316 MCHF is for the construction contracts. These contracts are based on a system of remeasurement whereby the consultant estimates the quantities required for the construction of each structure and the contractor commits himself to the unit price, which define the initial tender price. There are many factors that affect the final price for these contracts, from increases or decreases in quantities of the estimated amounts in the original bill of quantities to variations to the contract. This paper will look at how these factors change costs at the individual level of a structure to the overall costs of the contract. It will look at how the Civil Engineering Group monitors these changes to calculate cash flows and final costs and how this information is used as a basis for budget forecasts.

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1 INTRODUCTION

The civil engineering project for the LHC has been divided up geographically into four packages and hence four construction contracts. The total contract price of these contracts is 316 MCHF. The construction phase began in April 1998.

- Package 1 Underground and surface structures on the site of the ATLAS experiment.
- Package 2 Underground and surface structures on the site of the CMS experiment.
- Package 3a All the LHC structures except those of Packages 1, 2 and TI 8.
- Package 3b Injection tunnel TI 8.

In addition there are many other external specialists involved in this project; civil engineering consultants, architects, landscape architects, safety co-ordinators, surveyors, adjudicators and other specialist services that are called upon when required, bringing the total cost of the project to an estimated 350 MCHF. This paper will, however, focus on the construction contracts.

2 HOW DOES A CIVIL ENGINEERING CONTRACT WORK?

The consultant draws up the technical specification and a set of tender drawings. These drawings are only developed to the level of detail whereby the bidders for the contract are able to appreciate the requirements of the project. From the tender drawings the consultant estimates the quantities for every item in the contract. This is the Bill of Quantities (BoQ). The contractor inserts his unit price for each item in the BoQ when tendering for the contract. Construction drawings are drawn up by the consultant and the construction work is carried out by the contractor according to these drawings. The payment of the work, however, is based on the actual work carried out on site, where the quantities are remeasured and an exact price determined based on the unit price from the BoQ. This is called a system of remeasurement.

3 REASONS FOR CHANGES TO THE ESTIMATED CONTRACT PRICE

There are many factors that affect the initial estimated contract price of these contracts. Some of these factors are listed below.

- *Remeasurement.* The contract price is an estimated amount which may increase or decrease when the actual work is carried out on site when it is remeasured to determine the exact price.
- *New unit prices.* Items that were not foreseen in the BoQ will require new unit prices.
- *Modifications made by CERN.* Changes may be required as the project evolves.
- *Additional works.* There may be additional works carried out, requiring considerably larger quantities, though there may still be an existing price in the bill of quantities.
- *Alternative solutions.* Better alternative and/or cheaper solutions may be proposed and adopted.
- *Risks.* May include unknown ground conditions, exceptional circumstances, adverse weather conditions.

These changes to the initial estimated price, apart from the remeasurement, will be drawn up as a 'variation' to the contract. These variations are also estimated quantities until the actual work is carried out and the work remeasured on site. In the case of risks, however, they may either turn into 'variations' drawn up by the employer or into 'claims' made by the contractor.

4 COST MONITORING AND BUDGET FORECASTING

In view of the many ways in which costs can change, as discussed above, an internal budgeting system for the Civil Engineering Group has been set up to follow up all the costs for the civil engineering project for the LHC, which includes monitoring of the construction contracts.

Costs for these contracts are monitored to give an overview of the different ‘packages’ in the form of cashflows and to give a more detailed follow-up for each structure.

The four ‘packages’ are set up as cash flows with costs of the contract plotted on the Y-axis and time on the X-axis (Fig. 1). The tender forecast, the payments to date, and the current estimated forecast are shown. The tender forecast is the estimated contract price. The current estimated forecast is an estimate of significant changes which are likely to take effect, to give an indication of the general direction of costs. Thus the evolution of costs throughout the duration of the contract is monitored.

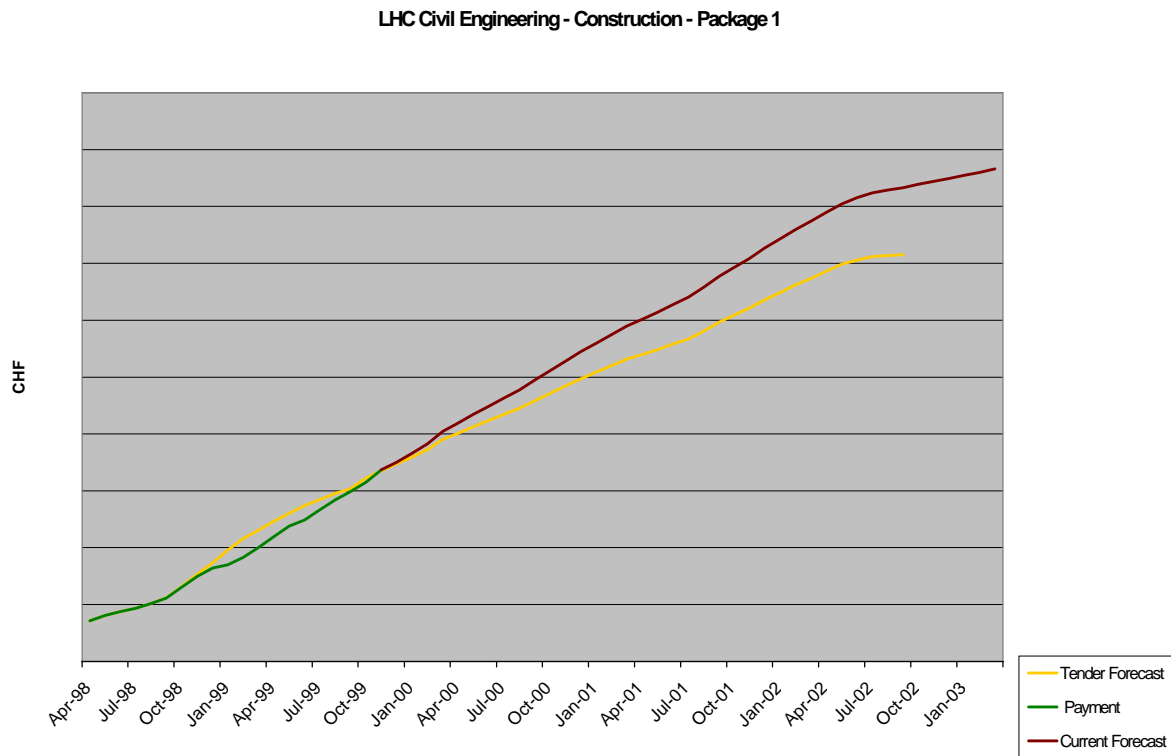


Figure 1: Cashflow – Package 1.

The four packages are also set out in more detail to show all the structures contained in each contract (Fig. 2). For each structure the initial estimated contract price, the proposed and agreed variations, claims and payments to date are shown. The estimated contract price comes from the BoQ. The proposed variations are variations from the estimated contract price which are in the pipeline and likely to come into effect in the near future. The agreed variations and claims are official and will take effect immediately. These variations and payments are systematically entered into the system and are automatically attributed to each structure. By monitoring costs at the detail of the structure, variances between the actual expenditure and the current estimated forecast in the cash flow can be adjusted.

Details of the variations are entered in a separate table and this information is easily accessible. From Fig. 2 it can be seen that increases or decreases in the estimated contract price for each structure can easily be identified. It is thus apparent that the SX1 building, the largest surface structure, has both ‘proposed’ and ‘agreed’ variations which represent a significant increase from the estimated contract price and should, therefore, be further analysed.

Package 1 - Contractors (Contract T052)							
Designation	Description	Contract Price	Variation Proposed	Variation Agreed	Claims Agreed	Contract Price + Agreed Variations	Cumulative Payment
01	Preliminary and General Items	25'415'878.70	0.00	-72'700.00	0.00	25'343'178.70	8'988'295.88
02	PX14 Access Shaft	3'695'813.80	0.00	-7'434.29	0.00	3'688'379.51	3'458'746.77
03	PX16 Access Shaft	2'515'537.60	0.00	-7'434.29	0.00	2'508'103.31	2'043'065.90
04	PX15 Access Shaft	713'261.00	0.00	33'041.47	0.00	746'302.47	1'174'661.69
05	UX15 Detector Cavern	15'178'909.40	0.00	-7'434.29	0.00	15'171'475.11	0.00
06	USA15 Technical Cavern	4'945'331.00	0.00	-7'434.29	0.00	4'937'896.71	627'965.07
07	UPX14 Personnel Access Tunnels	156'398.20	0.00	-7'434.29	0.00	148'963.91	0.00
08	UPX16 Personnel Access Tunnels	156'398.20	0.00	-7'434.29	0.00	148'963.91	0.00
09	ULX14 Service Connection Tunnels	175'801.80	0.00	-7'434.29	0.00	168'367.51	0.00
10	ULX15 Access Tunnel	220'811.50	0.00	-7'434.29	0.00	213'377.21	0.00
11	ULX16 Service Connection Tunnels	173'477.80	0.00	-7'434.29	0.00	166'043.51	0.00
12	UJ13 Junction Chamber	616'345.60	0.00	-7'434.29	0.00	608'911.31	0.00
13	UJ17 Junction Chamber	616'345.60	0.00	-7'434.29	0.00	608'911.31	0.00
14	UPS14 Survey Galleries and Transverse Bores	214'967.70	0.00	-7'434.29	0.00	207'533.41	0.00
15	UPS16 Survey Galleries and Transverse Bores	214'967.70	0.00	-7'434.29	0.00	207'533.41	0.00
16	RR13 Cyro Feedbox	803'512.90	0.00	0.00	0.00	803'512.90	0.00
17	RR17 Cyro Feedbox	803'512.90	0.00	0.00	0.00	803'512.90	0.00
18	variations		0.00	0.00	0.00	0.00	0.00
	Underground works total	56'617'271.40	0.00	-136'304.24	0.00	56'480'967.16	16'292'735.31
19	SX1 Building	5'949'698.05	608'467.61	373'524.81	0.00	6'323'222.86	5'688'850.32
20	SH1 Building	1'718'069.75	0.00	94'623.51	0.00	1'812'693.26	893'914.60
21	SDX1 Building	753'194.60	0.00	20'194.94	0.00	773'389.54	147'372.95
22	SUX1 Building	1'701'822.70	0.00	153'038.39	0.00	1'854'861.09	1'589'105.18
23	SCX1 Building	1'058'255.30	0.00	33'854.55	24'670.40	1'092'109.85	536'529.85
24	SGX1 Building and SGA1 Tank Foundations	544'501.55	0.00	0.00	0.00	544'501.55	550'779.13
25	SE1 Building	237'416.30	16'674.84	17'784.32	0.00	255'200.62	134'899.64
26	SY1 Building	370'158.10	221'053.58	1'556.51	0.00	371'714.61	642'768.19
27	SL14/SL15 Galleries	377'112.05	0.00	826.39	0.00	377'938.44	89'584.58
28	SEH1 Structures and Transformer Bases	141'751.00	0.00	8'392.01	0.00	150'143.01	82'288.85
29	Access Roads, Drainage and Services	1'886'281.60	25'952.00	43'808.79	0.00	1'930'090.39	1'075'139.29
31	Spoil dump	176'345.00	0.00	0.00	352'131.20	176'345.00	0.00
	Surface works total	14'914'606.00	872'148.03	747'604.24	376'801.60	15'662'210.24	11'431'232.58
	variations		0.00	0.00			
	Total (CHF)	71'531'877.40	872'148.03	611'300.00	376'801.60	72'143'177.40	27'723'967.89

Figure 2: Summary of structures for Package 1.

5 COST VARIATIONS FOR THE SX1 BUILDING

Further analysis was carried out to look at the reasons for the increase in the estimated contract price.

The demolition and site clearance was completed. The initial estimated price was 2 781CHF in and the remeasured executed works increased to 6 311CHF. This increase was due to the difficulty of initially quantifying how much work was required for site clearance and only became evident when the work was being carried out.

The excavation of the earthworks was then carried out, but owing to unforeseen ground conditions, parts of the ground were found to be composed of weak material and therefore further excavation and filling was required in some areas to form a firm foundation. This deeper excavation and filling was not foreseen in the tender BoQ and new rates were required at a price of 108 356 CHF and some of the initial estimated prices were not used. The initial estimated price of these works was 12 347 CHF and increased to 113 379 CHF.

Concrete work for the foundations required some extra items at a price of 30 838 CHF. The original estimated price was 686 820 CHF and the current executed works are 639 008 CHF. The costs, however, are likely to rise to 717 658 CHF as there are still some further works to be carried out such as the screeding.

Ancillaries to concrete works required some extra items, mainly reinforcement couplers, which would improve the overall quality of the work. The new rates amounting to 217 314 CHF.

The initial estimated price was 727 505 CHF. The current executed works are 721 775 CHF, but there are still some items to be completed and the costs are therefore likely to rise to 944 819 CHF.

Pre-cast concrete beams. This work has yet to be carried out and the estimated price is 853 129 CHF.

All piping work was omitted by the consultant. New unit prices were, therefore, required and the work was completed for a cost of 54 175 CHF.

Major metalwork needed extra items at a cost of 211 799 CHF as not enough detail was given in the original tender. The initial estimated cost was 1 6431 28. The current total executed works are 1 967 963 CHF. With a few minor works to be carried out costs are likely to rise to 1 972 786 CHF.

Minor ancillary and special metalwork are almost completed. There were extra items at a price of 294,706 CHF. This price was mainly due to a change of flooring for a higher quality solution. The initial estimated price was 849 336 CHF, which is likely to increase to 1 144 042 CHF when the works are completed.

Timber work was completed. There were extra items required at a price of 46 252 CHF. The original estimated price was 883 320 CHF and this alternative solution brought the price down to 832 773 CHF.

For the doors, windows and weatherproofing, not enough detail was given in the original tender for weatherproofing and a more detailed solution was given as a variation requiring new rates in many instances at a cost of 151 479 CHF. The original estimated price was 291 334 CHF. There are still some miscellaneous items, doors, and an arrest system to be completed, and therefore the price is likely to rise to 429 670 CHF.

This analysis illustrates how the factors listed in Section 3 can affect the initial estimated contract price. The significant increases in costs would seem to be due to unforeseen ground conditions in the excavation of the earthworks, a need for more detail in the weatherproofing, and improved quality solutions for reinforcement couplers and metal flooring.

The initial estimated contract price for the SX building was 5 949 699 CHF and the costs of the total works are estimated at 6 958 207 CHF, an increase of 17%. For surface works an increase of up to 15% would be considered acceptable. This is a slightly bigger increase than would normally be expected, and the analysis highlights the reasons for this increase.

6 CONCLUSION

Construction contracts form an important part of the civil engineering project for the LHC. As it was shown these contracts are based on a system of remeasurement and there can be many reasons why variations from the original estimated contract price occur. To be able to monitor these variations an internal budgeting system was set up to give both an overview of each 'package' or contract and more detailed costs for the individual structures.

As a result it is possible to foresee divergences from the contract price and draw up budget forecasts. Variances between actual expenditure and estimated forecasts can be followed up and adjustments made as they occur and it makes it possible to inform the hierarchy in a quick reliable way of changes.